VELVETLEAF (ABUTILON THEOPHRASTI)
RESPONSE TO CHLORAMBEN APPLIED POSTEMERGENT

by

Wendel Byron Orr

B.S., Kansas State University, 1981

MASTER'S THESIS

Submitted in partial fufillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1985

Loren J. Moshier

Major Advisor

ACKNOWLEDGEMENTS

A special thanks to Dr. Loren J. Moshier for the opportunity and the guidance he provided, to Professor Oliver G. Russ for his assistance and cooperation, and to committee members, Dr. Dave E. Kissel and Dr. Randall A. Higgins, for their suggestions and considerations.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Velvetleaf (*Abutilon theophrasti* Medic.) continues to be a serious problem for soybean (*Glycine max* (L.) Merr.) growers. Treatments of soil-applied herbicides at planting time often fail to provide adequate control. Growers therefore rely on herbicide applications and/or cultivation after soybean and velvetleaf emergence.

Adverse weather conditions early in the growing season in much of the North Central region of the U. S. often prevent timely postemergent herbicide applications and row cultivation. As a result, heavy velvetleaf infestations exist within this region. In 1983, Illinois Cooperative Extension specialists ranked velvetleaf second behind common cocklebur (*Xanthium pennsylvanicum* Wallr.) in severity among broadleaf weeds in soybeans in Illinois.

Velvetleaf competition effects on soybean. Several researchers have documented the effects of velvetleaf competition on soybean development and yield. Eaton et al. (1976) determined that velvetleaf seeded at soybean planting time at densities of approximately 130 seeds/m^2 and 204 seeds/m^2 in succeeding years reduced yields 32 percent when losses were averaged across years. They reported that pod number per plant was reduced more than other yield components such as seed weight and seeds per pod.

Hagood et al. (1980) reported that full season competition from velvetleaf at densities of 10, 20, and 40 plants/m^2 reduced soybean yields 43, 54, and 66 percent, respectively. Ten and 40 plants/m^2 reduced yields 40 and 50 percent in the second year of this study. These investigators determined that pod number per plant decreased from 50 pods per soybean plant in plots with no velvetleaf to 22 pods per plant when velvetleaf was present at densities of 10 plants/m^2. They also observed that velvetleaf competition reduced soybean leaf weight and leaf area.

Velvetleaf at one plant/30 cm of row through the entire season, reduced soybean yields 27 percent with early planting dates (Oliver 1979). Oliver correlated this 27 percent reduction with a 21 percent reduction in the crop growth rate. Velvetleaf removed at or within six weeks of soybean planting did not reduce the crop growth rate. Soybean growth rate did decline if velvetleaf was allowed to compete with soybeans for longer than six weeks but increased when velvetleaf was removed eight weeks after soybean planting. Removal up to eight weeks after soybean planting may reduce velvetleaf pressure in subsequent years as well as allow a yield increase in the current growing season. Chandler and Dale (1974) determined that velvetleaf can develop mature seed after 10 weeks with a potential production of 17,000 seeds/plant.

Recently work has been done on low residual populations of velvetleaf in competition with soybeans. Higgins et al. (1984) determined that full season velvetleaf competition at 1

and 2 plants/3.0 m of row reduced number of pods per plant and seeds per pod in the upper two thirds of the soybean canopy when the weeds were growing proximate (8 to 10 cm) to the soybeans for the entire season. Full season weed competition averaged across both densities reduced soybean yields 6 to 13.5 percent. Stoller and Woolley (1985) reported that velvetleaf at 1 and 2 plants/m^2 intercepted 44 to 56 percent of the sunlight concomitant with 19 to 26 percent soybean yield reductions.

Chloramben selectivity. Chloramben (3-amino-2,5-dichlorobenzoic acid), a substituted benzoic acid compound, was discovered as a plant growth regulator in the 1940's and introduced commercially in the 1950's as a selective soil-applied herbicide. It was initially marketed as a herbicide to control broadleaf and grassy weeds in both corn (*Zea mays* L.) and soybeans. During the last 20 years, chloramben has been used mainly in soybeans as a herbicide applied at planting to control broadleaf weeds. It is frequently combined with a dinitroaniline or acetanilide herbicide which control predominantly grasses. Recently, university and industry research trials have shown chloramben to have promise in reducing velvetleaf competition in soybeans when applied postemergent. Chloramben is currently labeled for postemergent applications up to 33 days after soybean emergence. Addition of a crop oil concentrate is recommended to increase foliar absorption by velvetleaf.

Several studies have been conducted to determine physiological basis of selectivity of root-applied chloramben in plants. Baker and Warren (1962) reported differences in translocation but not in absorption or metabolism between squash (Cucurbita pepo L.), a tolerant species, and cucumber (Cucumis sativus L.), a susceptible species. Colby (1966) detected more root-absorbed chloramben in shoots of pigweed (Amaranthus retroflexus L.), a susceptible species, than in shoots of soybean. In another study, Colby (1965) reported that most of root-absorbed chloramben is complexed to form a glucose conjugate in soybeans and barley (Hordeum vulgare L.) and that soybeans formed more of the conjugate than did barley. He suggested that formation of N-glucoside is a detoxication mechanism in soybeans. Swanson et al. (1966) identified the conjugate as N-(3-carboxy-2,5-dichlorophenyl)-glucosylamine and determined that this N-glucoside conjugate of chloramben is formed in roots of both tolerant and susceptible species. They provided evidence that the N-glucoside conjugate is non-phytotoxic and that tolerance or susceptibility of a species to chloramben may be dependent on the rate and amount of conjugate formed. Research by Stoller and Wax (1968) confirmed that tolerant species such as soybean, squash, and ivyleaf morningglory (Ipomoea hederacea L. Jacq.) form proportionately more N-glucoside conjugate of chloramben than do susceptible species such as velvetleaf and giant foxtail (Setaria faberi Herrm.).

Only one study has assessed the physiological basis for selectivity of chloramben when applied to foliage of plants

(Baker and Warren, 1962). In this study, Baker and Warren reported that cucumber foliage absorbed more chloramben than did squash and that both species translocated very little chloramben out of treated foliage. These investigators did not examine chloramben metabolism.

Root absorption of chloramben and atrazine applied postemergent. Baker and Warren (1962) reported soil applications of chloramben reduced growth of emerged plants more effectively than did foliage applications. Research with atrazine applied postemergent to grassy weeds indicated that atrazine must be root-absorbed to be completely effective (Thompson and Slife 1969). These researchers postulated that root absorption was necessary to expose the meristematic region of young grasses to atrazine. Meristematic exposure did not occur when atrazine was only absorbed by foliage. In a later study of atrazine applied postemergent to broadleaf weed species (including velvetleaf at 10 cm in height), Thompson and Slife (1970) determined that root uptake was not required for atrazine to be effective.

The present study was conducted to determine 1) efficacy of chloramben on velvetleaf treated at different growth stages, 2) effect of 2,4-DB addition or oil concentrate type on chloramben activity, and 3) effect on soybean yields when velvetleaf is treated with chloramben 20 days or later after planting.

MATERIALS AND METHODS

Greenhouse investigations. Growth stage effect on velvetleaf response to applications of chloramben combined with 2,4-DB and/or an adjuvant (crop oil concentrate) was evaluated under greenhouse conditions in two separate studies. In the first study, velvetleaf seed was planted 0.5 cm deep in 3.8 L pots containing a Muir silt loam soil (Typic Argiudoll). Successive planting dates were spaced approximately 14 days apart to achieve three growth stages. Pots were subirrigated until velvetleaf emerged and then were watered with sprinklers as necessary. The plants were grown in a 16-hour photoperiod regime with the aid of flourescent lighting and in a 32/20 C +/- 2 C day/night temperature regime. Seven to ten days after emergence, plants were thinned to four per pot and then later thinned to one or two plants per pot depending on growth stage.

Treatments were applied at the same time to velvetleaf plants at three different growth stages with a moving belt sprayer equipped with a stationary flat-fan nozzle delivering 187 L/ha at a pressure of 131 kPa with water as diluent. Nozzle height was adjusted to approximately 46 cm above the foliage. All plants at the most advanced growth stage (57 days after planting) were flowering and averaged 85 cm in height. The plants at the intermediate growth stage (38 days after planting) were at late vegetative to early flower bud stage and averaged 44 cm in height. Plants at least advanced growth

stage (30 days after planting) were at an early vegetative stage and averaged 11 cm in height. Treatments consisted of chloramben (formulated as a 75% dry water-soluble powder) at 3.4 kg acid equivalent (ae)/ha plus petroleum oil concentrate (commercial 83% paraffinic oil and 17% surfactant) at 2.3 L/ha and chloramben plus 2,4-DB (formulated as a 240 g ae/L aqueous solution) at 3.4 plus 0.034 kg ae/ha plus petroleum oil concentrate at 2.3 L/ha. Plants at each growth stage also were left untreated to provide controls.

Plants were weighed immediately after harvest to determine fresh weight, then dried for three days at 60 C and again weighed to determine dry weight. Percent water content within tissue was calculated by the equation: [(fresh weight-dry weight)/fresh weight] x 100.

In the second study, cultural procedures were similar to those used in the first study. Treatments consisted of chloramben at 3.4 kg ae/ha plus either petroleum oil concentrate or soybean oil concentrate (commercial 85% soybean oil and 15% surfactant) at 2.3 L/ha. Velvetleaf growth stages at the time of treatment were as designated in the first study in terms of phenological development although plant heights did vary from those in previous study.

Data presented are means of three and two experiments for first and second study, respectively. Values for each parameter for both studies were pooled from four subsamples within each experiment and were analyzed using a two-way factorial analysis with herbicide treatment and growth stage as factors. Means separated by Fisher's protected Least

Significant Difference (LSD) test. Variances of data, expressed as a percent of check, were determined to be homogeneous across combinations of both growth stages and herbicide treatments according to test suggested by Little and Hills (1978). Therefore, data was not transformed and reanalyzed.

Field investigations. A field study was conducted at Kansas State University South Agronomy Research Farm near Manhattan, KS in 1983 and 1984 to evaluate velvetleaf response to chloramben treatments. A site with a Reading silt loam soil (Typic Argiudoll) with 2.0% organic matter, pH 6.8, and high velvetleaf seed density was selected.

In 1983, the entire plot area was tilled with a power driven rotary cultivator on 27 May to destroy emerged weeds. One third of the plots was then left undisturbed for the remainder of the season to allow emergence of velvetleaf plants early in the growing season. On 9 June remaining plots were tilled and one half of these plots then left undisturbed to allow emergence of velvetleaf plants later in growing season. On 23 June, 28 days after the initial cultivation, the remaining plots were tilled and then left undisturbed. Soil moisture in 1983 was plentiful so that rapid emergence occurred in all three sets of plots when left undisturbed.

In 1984, initial tillage operation was performed on 9 May with the subsequent tillage operations on 31 May and 19 June. Again, rapid emergence occurred shortly after tillage due to plentiful soil moisture early in the season. In both years the

described tillage pattern allowed establishment of velvetleaf at three growth stages. Weeds other than velvetleaf were manually removed two to three times depending on velvetleaf growth stage.

Herbicide treatments consisted of chloramben at 3.4 kg ae/ha combined with either petroleum oil or soybean oil concentrate at 2.3 L/ha. These treatments were applied with a tractor-mounted sprayer equipped with flat fan nozzles delivering a volume of 187 L/ha at a pressure of 131 kPa with water as diluent. Velvetleaf at the three different growth stages were treated on the same day (21 July, 1983 and 19 July, 1984). The spray boom was adjusted to approximately 46 cm above the velvetleaf canopy. Plots at each growth stage also were left untreated to provide controls.

In 1983, the three growth stages at time of treatment with corresponding heights and growth periods were as follows: 1) flowering, 85 cm in height, and 53 days after plant (DAP); 2) vegetative, 50 cm in height, and 39 DAP; and 3) early vegetative, 13 cm in height, and 28 DAP. The three growth stages in 1984 were: 1) flowering, 1 m height, and 71 DAP; 2) late vegetative, 55 cm in height, and 49 DAP; 3) early vegetative, 31 cm in height, and 30 DAP.

Plants were harvested two weeks after treatments from two separate sections within each plot, each section 0.25 m^2 in area. Plants were weighed immediately after harvest, then dried for seven days at 60 C, and again weighed. Percent water content within tissue then was calculated. Capsules were

counted and collected in two separate 0.25 m^2 sections within each plot on 1 October, 1983 (plants at full maturity) and on 5 August, 1984. Seeds that still remained in capsules were removed. Substantially more seed was lost in 1983 than in 1984 due to dehiscence. Seed viability was measured by placing 50 seeds from each sample on moistened filter paper in petri dishes, allowing germination to occur in dark at 20 C, and then determining percent germination. The collected velvetleaf seed were placed in a water bath at 80 C for 1.5 minutes prior to germination test to break dormancy. This method is similar to those used by M. Horowitz and R.B. Taylorson (1984) and L.J. Lacroix and D.W. Staniforth (1965) to treat velvetleaf seed with seed coat impermeable to water. Seed harvested from untreated plants in 1983 and 1984 had germination percentages of 85 and 90 percent, respectively.

Herbicide treatments were replicated three times for each growth stage in a split-plot arrangement within a completely randomized design with growth stage as main plots and treatment as subplots. Means were separated by Fisher's protected LSD test.

A second field study was conducted at Kansas State University Cornbelt Experiment Farm near Powhattan, KS. on a Grundy silty clay loam soil (Aquic Argiudoll) with 1 percent organic matter, pH 5.7, and high velvetleaf seed density. The entire plot area was tilled immediately prior to soybean planting to destroy emerged velvetleaf plants. Alachlor (2-chloro-N-2,6-diethylphenyl)-N-(methoxymethyl)acetamide) was applied at 2.2 kg active ingredient/ha prior to planting and

mechanically incorporated to provide grassy weed control. Soybeans (Cumberland) were planted on 3 July 1984 in 76 cm rows with 12 seeds/30 cm of row.

Treatments consisted of chloramben at 3.4 kg ae/ha, 2,4-DB at 0.034 kg ae/ha, and chloramben plus 2,4-DB at 3.4 plus 0.034 kg ae/ha. All treatments included petroleum oil concentrate at 2.3 L/ha. Treatments were applied to a 2-m strip 9.1 m long centered on the two middle soybean rows of the 4 row plots. Applications were made approximately two weeks apart beginning 23 July when the soybeans were in the V3 stage (second trifoliolate leaves fully expanded) and velvetleaf was 20 DAP and 10 cm high. Other weed species were manually removed at this time. All applications were made in the late afternoon with a back pack sprayer equipped with flat-fan nozzles delivering a volume of 187 L/ha at a pressure of 168 kPa with water as a diluent. The hand-held boom was maintained at a height of 46 cm above velvetleaf canopy. Plots at each growth stage also were left untreated to provide controls.

Velvetleaf plants were harvested within two 0.25 m^2 sections in both treated and untreated areas within each plot two weeks after the last herbicide application. Treated sections were between the middle two soybean rows and untreated sections were between soybean rows adjacent to treated areas. Plants were weighed immediately after harvest, then dried for seven days at 60 C, and again weighed.

The two middle soybean rows were harvested with a plot combine in October. Velvetleaf was not removed from any of the plots so yield reductions also include harvest losses.

Treatments were replicated four times for each growth stage in a split-plot arrangement within a randomized complete block design with growth stage as main plots and treatments as subplots. Means for soybean yield were separated by Fisher's protected LSD. Means of velvetleaf weights expressed as a percent of check were separated by Fisher's protected LSD and tested against untreated means using a one sample t-test.

RESULTS AND DISCUSSION

Greenhouse investigations. Statistical analyses revealed that significant interaction did not exist between herbicide application and growth stage for either fresh or dry weight in either greenhouse study. Fresh and dry weight of treated plants expressed as percent of weight of untreated plants increased as stage of growth at time of treatment advanced (tables 1 & 3). Addition of 2,4-DB or type of oil concentrate did not affect chloramben activity (tables 2 & 4). Percent reduction in dry weights of treated plants ranged from 42 to 52 percent when averaged across three growth stages (tables 2 and 4). Dry weight of plants treated at the early vegetative stage was reduced 84 and 73 percent in the first and second study, respectively. Plants at the early growth stage in the first study averaged 11 cm in height and were treated 24 to 33 days after planting whereas plants at the early growth stage in the second study averaged 20 cm in height and were treated 38 to 45 days after planting. Dry weight reduction due to chloramben treatment was 52 and 14 percent, respectively, when plants were treated at the late vegetative and at flowering stages in the first study (table 1) and was 61 and 3 percent, when plants were treated at the same growth stages in the second study (table 3).

Chloramben treatments did not reduce plant water content except in one experiment of the first study when treatments at

Table 1. Velvetleaf response at three growth stages averaged across two treatments[a] (chloramben or chloramben plus 2,4-DB) in greenhouse experiments.

Growth stage	Fresh weight[b]	Dry weight[c]
	(% check)	(% check)
Early vegetative	15.1	15.6
Late vegetative	47.9	43.2
Flowering	86.0	70.7
LSD(.05)	24.5	21.7

[a]Petroleum oil concentrate added at 2.3 L/ha.
[b]Fresh weight for untreated plants averaged 36, 38, and 54g/plant.
[c]Dry weights for untreated plants averaged 7, 9, and 18g/plant.

Table 2. Velvetleaf response to chloramben and chloramben plus 2,4-DB averaged across three growth stages in greenhouse experiments.

Treatment[a]	Fresh weight	Dry weight
	(% check)	(% check)
Chloramben	48.1	42.3
Chloramben + 2,4-DB	51.3	44.0
LSD(.05)	NS	NS

[a]Petroleum oil concentrate added at 2.3 L/ha.

Table 3. Velvetleaf response at three growth stages averaged across two treatments (chloramben plus either petroleum oil concentrate or soybean oil concentrate) in greenhouse experiments.

Growth stage	Fresh weight[a]	Dry weight[b]
	(% check)	(% check)
Early vegetative	26.9	27.7
Late vegetative	39.2	39.5
Flowering	96.8	82.6
LSD(.05)	36.5	29.7

[a]Fresh weight for untreated plants averaged 36, 39, and 60g/plant.
[b]Dry weight for untreated plants averaged 6, 9, 17g/plant.

Table 4. Velvetleaf response to chloramben plus either petroleum oil concentrate or soybean oil concentrate averaged across three growth stages in greenhouse experiments.

Treatment	Fresh weight	Dry weight
	(% check)	(% check)
Chloramben + SOC[a]	58.5	52.6
Chloramben + POC[a]	50.1	47.2
LSD(.05)	NS	NS

[a]SOC=soybean oil concentrate; POC=petroleum oil concentrate.

the early growth stage killed plants within two weeks (data not reported). In that experiment, plants treated at the early vegetative stage were 8 to 11 cm in height and were eight days younger than plants treated at the early vegetative stage in second and third experiments of the same study. Water content of untreated plants averaged across both studies was 78, 76, and 70 percent for early vegetative, late vegetative, and flowering stage, respectively.

Epinasty of petioles connected to upper leaves which intercepted most of the spray droplets occurred within eight hours after chloramben application. After 24 hours, the portion of stem proximate to treated foliage was severely twisted and cracks lined with callus tissue appeared within this portion within one week. These injury symptoms occurred when the velvetleaf was treated at all growth stages. Stem epinasty and subsequent growth arrest caused treated plants to be 3 to 5 cm shorter two weeks after treatment than at time of treatment. Chloramben treatments at any growth stage caused only limited necrosis except in one experiment of one study when treated plants were completely killed.

It is difficult to assess growth stage effect on chloramben efficacy since treatments did not cause immediate dessication and growth rates were not determined during the two week interval between treatment and harvest. Plants at the flowering stage will have accumulated most of their biomass (fresh or dry weight) by time of treatment and therefore biomass would not differ greatly between untreated plants and plants treated with chloramben. Data do indicate

that chloramben effectively reduces growth of velvetleaf plants treated at a time (early vegetative stage) when more rapid growth is occurring. Delay in plant development was observed in chloramben-treated plants at all growth stages two weeks after treatment. Untreated plants had formed flower buds whereas plants treated at the early vegetative growth stage had not formed flower buds when harvested. Untreated plants were flowering and starting to produce seed capsules whereas plants treated at the late vegetative stage had formed only flowers which were smaller than those in untreated plants and were malformed. Also, capsules were larger and more abundant in untreated plants than on plants treated at flowering stage.

Field investigations. Results from the field study conducted at the South Agronomy Research Farm near Manhattan were similar to those obtained in the comparative study under greenhouse conditions. Fresh and dry weight of treated plants expressed as percent of weight of untreated plants increased in 1983 as stage of growth at time of treatment advanced (Table 5). A similar trend was observed in 1984. Plants treated in 1984 were 3, 8, and 18 days older at the early vegetative, late vegetative, and flowering stages, respectively, than plants treated at the same growth stages in 1983. Velvetleaf response to chloramben was not influenced by oil concentrate type in either year (Table 6). In 1983, chloramben treatments reduced plant water content 42 percent at the early vegetative stage and had no effect on plant water content at the two later growth stages (data not presented). In 1984,

Table 5. Velvetleaf response at three growth stages averaged across two treatments (chloramben plus petroleum oil concentrate or soybean oil concentrate) in field experiments conducted near Manhattan.

Growth stage	Fresh weight[a]		Dry weight[a]		Capsule count[b]		Germination[c]	
	1983	1984	1983	1984	1983	1984	1983	1984
	(% check)							
Early vegetative	33.7	53.4	52.5	48.8	11.0	10.1	17.5	28.3
Late vegetative	77.8	92.1	85.9	74.5	27.5	9.7	52.5	7.9
Flowering	87.7	91.1	95.0	87.6	31.6	71.8	79.2	72.1
LSD(.05)	24.4	40.6(NS)	20.7	32.0	19.7	30.2	30.0	42.0

[a]Actual check weights(grams); 1983-fresh(dry)=614(156), 970(266), 975(265).
1984-fresh(dry)=536(120), 552(145), 813(174).
[b]No treatment capsule counts; 1983=222, 218, 218 1984=160, 174, 272.
[c]No treatment germination percentages; 1983=83, 73, 72 1984=77, 95, 92.

Table 6. Velvetleaf response to chloramben plus either petroleum oil concentrate or soybean oil concentrate averaged across three growth stages in field experiments.

Treatment	Fresh weight		Dry weight		Capsule count		Germination	
	1983	1984	1983	1984	1983	1984	1983	1984
	(% check)							
Chloramben + SOC	64.4	72.3	77.0	66.4	28.1	31.7	43.8	41.9
Chloramben + POC	68.4	85.4	78.7	74.4	18.7	29.3	55.7	30.2
LSD(.05)	NS	NS	NS	NS	NS	NS	NS	NS

water content of treated plants was not significantly different from the water content of untreated plants. Plant water content of untreated plants was 74, 72, and 73 percent at the early vegetative, late vegetative, and flowering growth stages, respectively, in 1983 and was 78, 74, and 70 percent at the respective growth stages in 1984.

Injury symptoms observed in the field were the same as those observed in the greenhouse studies and were visible during the entire season. Apparently a sufficient amount of chloramben that entered into the velvetleaf plant through the foliage remained unaltered to allow injury to persist even ten weeks after treatment.

Chloramben treatments reduced velvetleaf reproduction potential both years (tables 5 & 6). Capsule counts were reduced 89, 74, and 68 percent when chloramben treatments were applied at early vegetative, late vegetative, and flowering stage, respectively, in 1983 and were reduced 90, 90, 28 percent when plants were treated at the respective growth stages in 1984. The reduced effectiveness of the chloramben treatments at the flowering stage in 1984 was attributed to the maturity of the plants at that growth stage.

Germination of seed, harvested from treated plants, was reduced 92, 47, and 21 percent when plants were treated at the early vegetative, late vegetative, and flowering stages, respectively, in 1983 and were reduced 72, 91, and 28 percent when plants were treated at the respective growth stages in 1984. Germination of velvetleaf seed harvested from

untreated plants averaged 85 percent in 1983 and 90 percent in 1984. Foliarly-absorbed chloramben is immobile in treated plants (Baker and Warren 1962) and therefore would be present in insufficient quantity within reproductive tissue that developed after treatment to cause physiological disruption. Reproduction in capsule production and seed viability in treated plants is probably caused by the physical blocking of vascular tissue within leaves and stems where chloramben absorption has occurred.

Analysis of fresh and dry weight data expressed as percent of untreated velvetleaf from study conducted near Powhattan in 1984 indicated that a significant interaction did not occur between treatments and growth stage. Data averaged across stages of growth revealed that chloramben activity was not increased by additions of 2,4-DB (table 7). Two,4-DB applied alone with oil concentrate significantly increased velvetleaf weight compared to untreated plant weights (tables 7 and 8). This response may be due, in part, to the fact that 2,4-DB is an auxin type chemical that could stimulate growth when applied at sublethal rates as in this study.

Soybean yields averaged 1350 and 1140 kg/ha higher in plots treated 20 days after planting with chloramben alone and choramben plus 2,4-DB, respectively, than in untreated plots (table 9). Velvetleaf plants treated at the earliest date averaged seven cm in height and were effectively controlled by chloramben treatments. Chloramben, 2,4-DB, and chloramben plus 2,4-DB applied 34 and 48 days after planting did not increase yields. Velvetleaf plants treated at these later

Table 7. Velvetleaf response to herbicide treatments averaged across three growth stages in 1984 at Powhattan, KS.

Treatment	Fresh weight[a]	Dry weight[b]
	------------(% check)------------	
Chloramben	71	68
2,4-DB	145	152
Chloramben + 2,4-DB	81	75
LSD(.05)	43	46

[a]Fresh weights of untreated plants ranged from 433 to 721g/0.05 m^2.
[b]Dry weights of untreated plants ranged from 142 to 217g/0.05 m^2.

Table 8. Least squares means analysis of chloramben treatments to determine if herbicide treatments differ from no treatment.

Treatment	Dry weight percent LSmean	Standard error LSmean	Test HO:mean=1
Chloramben	.6823	.1569	**
2,4-DB	1.5180	.1569	**
Chloramben + 2,4-DB	.7467	.1569	NS

** $p<0.025$

dates were not as susceptible to chloramben as when treated at the earlier date. We felt that the competition of the velvetleaf prior to and after herbicide treatments prevented the occurrence of a yield response.

Table 9. Soybean yield response to velvetleaf treated with chloramben treatments at three growth stages in 1984 at Powhattan, KS.

Treatment	Velvetleaf growth stage	Soybean yield
		(kg/ha)
Chloramben	Early vegetative	2151
	Late vegetative	1004
	Flowering	948
2,4-DB	Early vegetative	635
	Late vegetative	1058
	Flowering	847
Chloramben + 2,4-DB	Early vegetative	1947
	Late vegetative	1114
	Flowering	766
No treatment		809
LSD(.05) within growth stages		334
LSD(.05) between growth stages		439

LITERATURE

Literature Cited

Baker, R. S. and G. F. Warren. 1962. Selective herbicidal action of Amiben on Cucumber and Squash. Weeds 10:219-224.

Barker, M. A., L. Thompson Jr., and R. Patterson. 1984. Effect of 2,4-DB on soybans. Weed Sci. 32:299-303.

Chandler, J. M., and J. E. Dale. 1974. Comparative growth of four malvaceous species. Proc. South. Weed Sci. Soc. 27:116-117.

Colby, S. R. 1965. Herbicide metabolism: N-glycoside of Amiben isolated from soybean plants. Science 150:619-620.

Colby, S. R. 1966. The mechanism of selectivity of Amiben. Weed Sci. 14:197-201.

Eaton, B. J., O. G. Russ, and K, C. Feltner. 1976. Competion of velvetleaf, prickly sida, and Venice mallow in soybeans. Weed Sci. 24:224-228.

Fehr, W. R., C. E. Cavines. 1980. Stages of soybean development. Iowa Cooperative Extension Service SR 80.

Hagood, E. S., T. T. Bauman, J. L. Williams Jr., and M. M. Schreiber. 1980. Growth analysis of soybean (Gycine max) in competition with velvetleaf (Abutilon theophrasti). Weed Sci. 28:729-734.

Higgins, R. A., L. P. Pedigo, and D. W. Staniforth. 1984. Effect of velvetleaf competition and defoliation simulating a green cloverworm (Lepidoptera: Noctuidae) outbreak in Iowa on indeterminate soybean yield, yield components, and economic decision levels. Environmental Entomology 13:917-925.

Horowitz, M. and R. B. Taylorson. 1984. Hardseededness and germinability of velvetleaf as afected by temperature and moisture. Weed Sci. 32:111-115.

LaCroix, L. J. and D. W. Staniforth. 1965. Seed dormancy in velvetleaf. Weeds 12:171-174.

Little, T. M. and F. J. Hills. 1978. Agricutural experimentation, design and analysis. John Wiley and Sons, NY,NY. 1-345.

Oliver, L. R. 1979. Influence of soybean (Glycine max) planting date on velvetleaf (Abutilon theophrasti) competition. Weed Sci. 27:183-188.

Stoller, E. W. and L. M. Wax. 1968. Amiben metabolism and selectivity. Weed Sci. 16:283-288.

Stoller, E. W. and J. T. Woolley. 1985. Competition for light by broadleaf weeds in soybeans (Glycine max). Weed Sci. 33:199-202.

Swanson, C. R., R. E. Kadunce, R. H. Hodgson, and D. S. Frear. 1966. Amiben metabolism in plants. I. Isolation and identification of an N-glycosyl complex. Weed Sci. 14:319-323.

Swanson, C. R., R. E. Kadunce, R. H. Hodgson, and H. R. Swanson. 1966. Amiben metabolism in plants. II. Physiological factors in N-glycosyl amiben formation. Weed Sci. 14:323-327.

Thompson, L., Jr. and F. W. Slife. 1969. Foliar and root absorption of atrazine applied postemergence to giant foxtail. Weed Sci. 17:251-256.

Thompson, L., Jr. and F. W. Slife. 1970. Root and foliar absorption of atrazine applied postemergence to broadleaf weeds. Weed Sci. 18:349-351.

APPENDIX

Table 10. Analysis of Variance summary of pooled fresh and dry weighs for greenhouse study one.

Source	Df	Mean fresh weight (% check)		Mean dry weight (% check)	
		MS	F-value	MS	F-value
Experiment	2	.0974	2.68	.0779	2.74
Treatment (TMT)	1	.0044	0.12	.0012	0.04
Growth stage (SOG)	2	.7568	20.82**	.4566	16.09**
TMT x SOG	2	.0021	0.06	.00002	0.00
Error	10	.0363		.0284	

** denotes significance at the 0.01 level.

Table 11. Analysis of Variance summary of water content for greenhouse study one.

Source	Df	Water content (%)	
		MS	F-value
Experiment	2	.0345	3.68*
Treatment (TMT)	2	.0056	0.60
Growth stage (SOG)	2	.0465	4.96**
TMT x SOG	4	.0378	4.03**
Error	97	.0094	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 12. Analysis of Variance summary of pooled fresh and dry weights for greenhouse study two.

Source	Df	Mean fresh weight (% check)		Mean dry weight (% check)	
		MS	F-value	MS	F-value
Experiment	1	.0473	1.17	.0682	2.56
Treatment (TMT)	1	.0211	0.52	.0087	0.53
Growth stage (SOG)	2	.5574	13.80**	.3339	12.54*
TMT x SOG	2	.0126	0.31	.0063	0.24
Error	5	.0404		.0266	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 13. Analysis of Variance summary of water content for greenhouse study two.

Source	Df	Water content (%)	
		MS	F-value
Experiment	1	.1148	129.0**
Treatment (TMT)	2	.0011	1.23
Growth stage (SOG)	2	.0130	14.6**
TMT x SOG	4	.0027	3.07*
Error	62	.0009	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 14. Analysis of Variance summary of field experiment conducted near Manhattan in 1983.

Source	Df	Fresh weight (% check)		Dry weight (% check)		Capsule count (% check)		Germination (% check)	
		MS	F-value	MS	F-value	MS	F-value	MS	F-value
Growth stage (SOG)	2	.4964	16.65**	.3011	14.03**	.0711	3.65	.5745	12.70**
REP(SOG)	6	.0298	0.99	.0214	1.01	.0195	1.20	.0452	0.38
Treatment (TMT)	1	.0069	0.23	.0013	0.06	.0391	2.41	.0641	0.54
SOG x TMT	2	.0023	0.08	.0006	0.03	.0013	0.08	.0566	0.48
Error	6	.0213		.0213		.0162		.1187	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 15. Analysis of Variance summary of water content for field experiment conducted near Manhattan in 1983.

Source	Df	Water content (%)	
		MS	F-value
Growth stage (SOG)	2	.0159	5.92*
REP(SOG)	6	.0027	2.68
Treatment (TMT)	2	.0155	15.48**
SOG x TMT	4	.0063	6.26**
Error	12	.0010	

* denotes significance at the 0.05 level.
** denotes significacne at the 0.01 level.

Table 16. Analysis of Variance summary of field experiment conducted near Manhattan in 1984.

Source	Df	Fresh weight (% check)		Dry weight (% check)		Capsule count (% check)		Germination (% check)	
		MS	F-value	MS	F-value	MS	F-value	MS	F-value
Growth stage (SOG)	2	.2923	3.53	.2352	4.58	.7769	16.82**	.6458	7.31*
REP(SOG)	6	.0827	0.41	.0513	0.49	.0456	1.68	.0884	0.69
Treatment (TMT)	1	.0779	0.39	.0289	0.28	.0027	0.10	.0615	0.48
SOG x TMT	2	.0281	0.14	.0043	0.04	.0262	0.97	.0210	0.16
Error	6	.2010		.1049		.0271		.1284	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 17. Analysis of Variance summary of water content for field experiment conducted near Manhattan in 1984.

Source	Df	Water content (%)	
		MS	F-value
Growth stage (SOG)	2	.0127	32.12**
REP(SOG)	6	.0004	0.67
Treatment (TMT)	2	.0014	2.42
SOG x TMT	4	.0003	.48
Error	12	.0006	

* denotes significance at the 0.05 level.
** denotes significacne at the 0.01 level.

Table 18. Analysis of Variance summary of field study conducted at Powhattan in 1984.

Source	Df	Fresh weight (% check)		Dry weight (% check)	
		MS	F-value	MS	F-value
REP	3	.5276	2.13	.3144	1.06
Growth stage (SOG)	2	4.2554	9.12*	3.9862	6.88*
REP x SOG	6	.4665	1.89	.5796	1.96
Treatment (TMT)	2	1.9580	7.91**	2.5953	8.78**
TMT x SOG	4	.5434	2.20	.5771	1.95
Error	18	.2475		.2956	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

Table 19. Analysis of Variance summary of soybean yield for field study conducted at Powhattan in 1984.

Source	Df	MS	F-value
REP	3	15964	0.30
Growth stage (SOG)	2	1348001	9.36*
REP x SOG	6	143985	2.72*
Treatment (TMT)	3	304136	5.75**
TMT x SOG	6	311552	5.89**
Error	27	52927	

* denotes significance at the 0.05 level.
** denotes significance at the 0.01 level.

VELVETLEAF (<u>ABUTILON THEOPHRASTI</u>)

RESPONSE TO CHLORAMBEN APPLIED POSTEMERGENT

by

Wendel Byron Orr

B.S., Kansas State University, 1981

AN ABSTRACT OF A MASTER'S THESIS

Submitted in partial fufillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1985

Greenhouse and field studies were initiated to evaluate efficacy of chloramben (3-amino-2,5-dichlorobenzoic acid) plus petroleum oil concentrate, chloramben plus soybean oil concentrate, and chloramben plus 2,4-DB plus petroleum oil concentrate when applied to foliage of velvetleaf (*Abutilon theophrasti* Medic.) plants at three growth stages. Chloramben plus oil concentrate applied at 3.4 kg acid equivalent (ae)/ha plus 2.3 L/ha reduced fresh and dry weight less as growth stage advanced. Oil concentrate type or the addition of 2,4-DB did not influence the activity of chloramben plus oil concentrate. In the field, dry weight of velvetleaf in pure stands was reduced 47 and 51 percent when chloramben treatments were applied to velvetleaf at an early vegetative growth stage in two successive years. Growth of velvetleaf plants treated at a late vegetative stage was reduced 14 and 25 percent in successive years. Growth reduction was less than 15 percent when velvetleaf was treated at flowering. Number of capsules produced by plants treated at all growth stages was reduced 70 percent or more when compared to number of capsules produced by untreated plants in one year and was reduced 90, 90, and 28 percent when treated at early vegetative, late vegetative, and flowering stages, respectively, in the second year. Viability of seed, harvested from plants treated at early vegetative, late vegetative, or flowering stage was reduced 82, 47, 21 percent, respectively for one year and was reduced 72, 92, and 28 percent when plants were treated at respective growth stages in a second year. Soybean (*Glycine*

max (L.) Merr.) yields were significantly increased when chloramben treatments were applied to competing velvetleaf 20 days after planting but not when applied 34 days or 48 days after planting.